

Submental/submandibular intubation: a journey from past to future

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In 1986, Altemir published the first article on submental intubation as an alternative to tracheostomy for managing difficult airways. This review provides an overview of submental/submandibular intubation, covering its development, techniques, and clinical outcomes. Initially devised to address difficult airways in oral and maxillofacial surgery, the technique has since evolved. Recent advancements include focused surgical incisions, ultrasound-guided imaging, and the use of improved procedural tools like the Seldinger technique. Clinical trials have demonstrated that submental/submandibular intubation is generally more efficient and quicker than tracheostomy in trauma patients. One of its key advantages is the absence of visible scarring, along with a less invasive recovery process. However, the technique has some limitations, including risks of infection, bleeding, and scarring, which require further investigation to optimize its application. While submental/submandibular intubation remains a valuable method for managing difficult airways, ongoing refinement and evaluation are necessary to maximize its clinical utility. This technique presents an excellent alternative in specific surgical scenarios and offers a simplified solution where other intubation methods may be unfeasible.

Keywords: Complications; Intubation; Safety; Submandibular; Submental; Tracheostomy.

INTRODUCTION

Submental intubation (SI) was first introduced by Altemir [1] in 1986. Before this technique, surgeries involving the face, pharynx, and skull base required orotracheal or nasotracheal intubation, with tracheostomy being the only alternative when these were contraindicated. SI was developed as a less invasive alternative to tracheostomy, particularly in cases where both orotracheal and nasotracheal intubation are not viable options.

The procedure begins with oral intubation, followed by a transverse incision in the submental area. A tunnel is created through dissection, and the tube is guided through the tunnel, exiting below the chin using a hemostat. The tube is

secured in place to facilitate the surgery. Once the procedure is completed, the tube is repositioned into the oral cavity through the same tunnel, and the incision is closed, allowing for safe extubation [2].

As of July 2024, a PubMed search identifies 96 articles with "submental intubation" and 9 with "submandibular intubation" in their titles, underscoring the technique's potential but highlighting the need for further validation. Despite its usefulness, many anesthesiologists are unfamiliar with it, and some express discomfort with its use. This narrative review aims to explore the evolution of submental/submandibular intubation (SSI), examining modifications in technique, their impact on airway management, and areas for further development. By analyzing procedural changes, it

identifies advancements that have improved patient outcomes. It also examines the clinical scenarios where SSI is most often performed, including trauma surgery, maxillofacial procedures, and situations where nasotracheal or orotracheal intubation is contraindicated. This review offers a comprehensive overview of SSI techniques, indications, and applications, highlighting innovations that have enhanced the safety and efficiency of the procedure in modern surgical practice.

METHODS

A comprehensive search was conducted on PubMed using the terms 'submental intubation' or 'submandibular intubation' in titles, reviewing all relevant articles. Studies focusing on the use of SSI in oral and maxillofacial surgery were selected. Emphasis was placed on case reports, letters, randomized controlled trials introducing new or revised techniques, and review articles, which were prioritized for inclusion. SI is defined as intubation through a tunnel created in the submental triangle. Submandibular intubation refers to a paramedian approach within the submandibular triangle for SI. When referring to prior literature, this review uses terminology as presented in the original studies.

ANATOMICAL LOCATION OF SSI

In 1986, Altemir [1] described the technique involving oral intubation, followed by a 2 cm incision parallel to the mandibular lower border, about one finger-width below it. A tunnel was created to the oral floor, and the tube was guided out using a curved hemostat [1]. The submental triangle is a triangular area formed by the anterior belly of the digastric muscle and the hyoid bone. In a 2003 correspondence, Altemir further recommended a paramedian approach in the submandibular triangle rather than a median approach [3] to avoid damaging structures such as the anterior belly of the digastric muscle, the insertion site of the geniohyoid muscle, and the Wharton (submandibular) duct. The paramedian approach, considered safer anatomically, corresponds to the submandibular triangle, formed by the anterior and posterior bellies of the digastric muscle and the ramus of the mandible [3]. The specific incision is placed at the anterior vertex of the submandibular triangle, parallel to the mandibular lower border. Care should be taken to avoid the submandibular gland laterally and the sublingual gland medially.

Using the Essential Anatomy 5 (3D4Medical, Elsevier) application, the relevant anatomical structures can be visualized in detail (Fig. 1). As shown in Fig. 1, when performing submandibular intubation via the paramedian approach (submandibular triangle), care must be taken around the submandibular gland. While the vascular structures in this region can appear complex, the submental artery and vein, which run just below the mandible, are not significantly impacted by the incision. Despite anatomical variations among patients, avoiding the submandibular duct minimizes the risk of damage, making SI relatively safe.

Cadaver studies have shown that placing a 2 cm submental incision about one finger-width below the mandible and dissecting through the skin, subcutaneous fat, platysma muscle, and subplatysmal fat exposes the mylohyoid muscle. Beneath it lie the genioglossus muscle, which forms the base of the tongue, and the geniohyoid muscle. Further dissection of the genioglossus reaches the oral mucosa, allowing for safe SI without significant damage to other structures [4].

TECHNIQUES FOR SSI

This section reviews the development of the SI concept, first introduced in 1986, and its evolution to the present day. Table 1 outlines the progression of SSI techniques over time and the complications reported, which will be explored in detail in the following sections.

In the systematic review by Goh et al. [5], the SSI technique was described as follows: a paramedian approach for the incision was used in 1,153 patients (51.7%), while the median approach was used in 736 patients (33.0%). For the remaining 15.3% of cases, no data were available regarding the approach used. Regarding the devices, the reinforced tube, which contains an internal metal coil to prevent kinking when bent, was used in 1,896 patients (85.1%), making it the most frequently used device. Non-reinforced tubes were used in 16 patients (0.7%). Although a small number of cases used laryngeal mask airways (LMA) or combitubes® (Tyco-Healthcare-Kendall-Sheridan), these were also identified. Data for 7.9% of the total patients were not collected. The one-tube technique, proposed by Altemir [1], involves withdrawing the oral intubation tube through the submental incision and was used in 83.9% of cases. The two-tube technique, described by Green and Moor [6], involves creating a submental incision after oral intubation, inserting a new tube through the tunnel, and exchanging the initially intu-

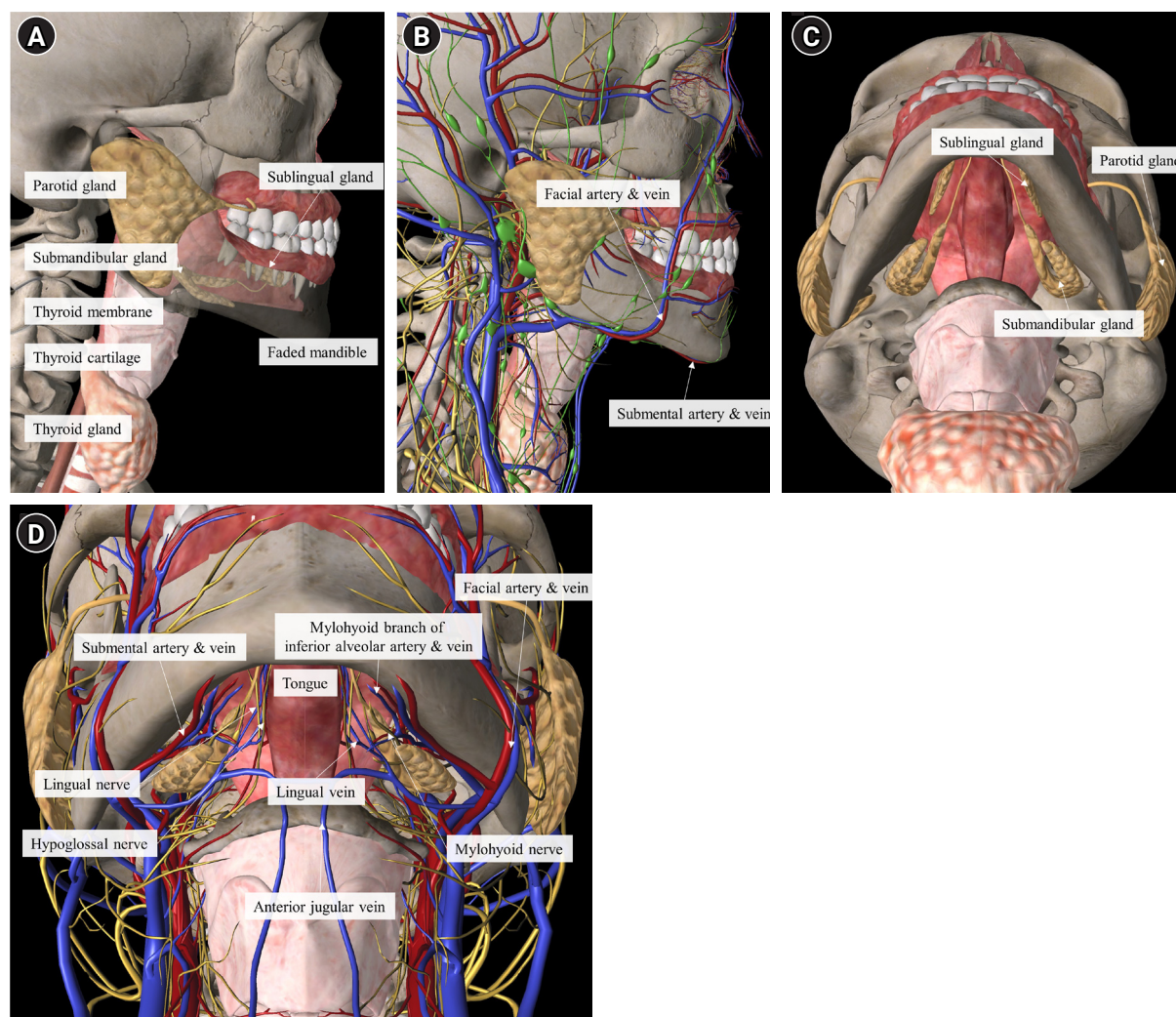


Fig. 1. Examination of anatomical structures surrounding submental/submandibular intubation using the Essential Anatomy 5 (3D4Medical, Elsevier) application. (A, B) Lateral view. (C, D) Submental and submandibular area. When using the paramedian approach for submandibular intubation, care is needed around the submandibular gland, though key vascular structures like the submental artery and vein are generally unaffected by the incision line.

bated tube with the newly inserted one. This method was used in approximately 6.2% of cases. Data for the remaining 9.9% of cases were not collected [5]. According to Altemir's original method, the skin incision length was 2 cm, though later studies reported incisions between 1 and 2 cm. A 2018 review article compared incisions lengths: 2 cm was used in 612 cases (59.9%), 1.5 cm in 325 cases (31.8%), and 1 cm in 7.8% of cases [7]. Techniques and equipment used in SSI from these two review articles have been analyzed and visualized in Fig. 2 for clarity.

Advent of SI in 1986 [1]

As mentioned earlier, SI was first introduced in 1986, with

the initial report describing the use of a curved hemostat to create a paramedian incision and perform the one-tube technique. A nasal speculum was used to prevent dislodgement of the endotracheal tube (ETT) and to avoid blood or soft tissue entry into the tube lumen.

Following this initial publication, several modifications were introduced to address discomforts encountered during the procedure, with the aim of securing the airway effectively and safely through the submental route.

Between 1990 and 2000

In 1996, a two-tube method for SI was introduced, particularly for patients with extensive facial and skull base frac-

Table 1. Various Techniques of Submental/Submandibular Intubation

Author	Year	Patients	Number of patients	Techniques used	Reported complications
Altemir [1]	1986	N/A	N/A	Using a curved hemostat to dissect structures at the paramedian site, the one-tube technique is performed, and a nasal speculum is used to secure the submental route.	None
Green et al. [6]	1996	Extensive facial fracture, Skull base fracture	1	Perform oral intubation with the first endotracheal tube, and then insert the second reinforced tracheal tube intraorally through the submental incision, replacing the existing oral tube.	None
MacInnis et al. [8]	1999	Cranio-maxillofacial trauma, orthognathic surgery	15	To reduce bleeding and minimize damage to structures, use a midline approach behind Wharton's duct.	None
Altemir et al. [9]	2000	Maxillary, alveolar and nasal fractures	3	LMA used instead of ETT.	N/A
Nwoku et al. [10]	2002	Panfacial fracture, Orthognathic surgery	10	Perform modified submental intubation by making a laterosubmental incision in the submandibular region.	None
Altemir et al. [11]	2003	Severe maxillofacial trauma	2	Combitube® used instead of ETT.	None
Lim et al. [12]	2003	Multiple facial bone fractures	1	Insert the pilot balloon and the proximal end of the endotracheal tube, disconnected from the tube connector, into the blue cap of a 33Fr thoracic catheter, and pass it through the submental tunnel.	None
Yoon et al. [13]	2004	Multiple facial bone fractures	1	Use a 20 G needle connector to attach a new pilot balloon to the endotracheal tube with the detached balloon.	None
Kim et al. [14]	2005	Panfacial fracture	2	Wire-reinforced tube (LMA-Fastrach™) used instead of conventional ETT.	None
Taglialatela et al. [15]	2006	Panfacial injuries	107	Create a passage in the anterior submandibular area for intubation and coined the term "Submento-submandibular intubation."	Suppuration in the cutaneous wound (11), salivary fistula (8), reintubation due to the cuff of the second tube breaking (6)
Nyárády et al. [16]	2006	Elective orthognathic cases	8	A sterile nylon guiding tube and the '222 rule' incision were used.	None
Biswas et al. [17]	2006	N/A	2	Percutaneous dilatational tracheostomy kit (dilator) for submental tunneling.	N/A
Lima et al. [18]	2011	Maxillofacial injuries	15	Cover the distal end of the tube with the finger portion of a surgical glove and pass it through the submental tunnel.	None
Saheb et al. [19]	2014	Major cranio-maxillofacial fractures	4	Seldinger's technique with a percutaneous dilatational tracheostomy kit for submental tunneling.	None
Kita et al. [20]	2016	Maxillofacial fractures	25	Passing the endotracheal tube through a silicone tube involves inserting the endotracheal tube into the lumen of a silicone tube and advancing it through the desired pathway or tunnel.	Dislodged into the right main bronchus (1), skin infections (2)
Ujam et al. [21]	2017	Midface injuries	1	Use the Blue Rhino® device from the percutaneous tracheostomy set to perform submental tunnel dilation and pass the ETT through.	None
Oshima et al. [22]	2018	Panfacial fractures	7	Passing through a single submental tunnel using 2-0 silk suture and 2 forceps.	Erroneous passage (1)
Jung et al. [23]	2020	Fractures of the zygomaticomaxillary, zygomatic arch, and right inferior orbital floor	1	Perform submental tunneling using the 12-mm diameter lumen of a laparoscopic trocar and pass the endotracheal tube through the trocar's lumen.	None
Yun et al. [24]	2020	Lefort I fracture, Lefort II fracture, infraorbital wall fracture, maxillary anterior alveolar fracture, and sinus anterior wall fracture	1	Use the Sani-sleeve™ (SDCCD) to pass the tube through the tunnel.	None

(Continued to the next page)

Table 1. Continued

Author	Year	Patients	Number of patients	Techniques used	Reported complications
Jacob et al. [4]	2020	N/A	1	Reinforced ETT where the connector cannot be detached, involving excising the connector with a scalpel and replacing it with a smaller connector.	None
Silveira et al. [25]	2020	N/A	N/A	Use a conical punch device, coupled cylinder pliers, tongue retractor, and drilling guide.	None
Jeon et al. [26]	2022	1. Le Fort II fracture, nasoethmoidal fracture, orbital wall fracture, mandible fracture, and basal skull fracture 2. Panfacial fracture 3. Panfacial fracture 4. Panfacial fracture with traumatic subarachnoid hemorrhage 5. Panfacial fracture with traumatic subdural hemorrhage	13	1. Disconnect the endotracheal tube connector and connect it to a nelaton catheter to pass through the submental tunnel. 2. Separate the connector and connect a suction connector to the proximal end of the tube to pass through the tunnel. 3. Fix a dental needle cap with loban on the proximal end of the tube after disconnecting the connector and use a hemostat in the submental area to pull and secure the needle cap through the tunnel. 4. Use a nasal speculum in the submental tunnel to widen the passage. 5. Perform submental tunneling using a laparoscopic trocar.	Separation of nelaton tube (1), broken suction connector (1), dual submental routes (1), damaged soft tissue (N/A)
Bihani et al. [28]	2023	Panfacial trauma	10	Ultrasonography-guided Seldinger technique for submental tunneling.	Minor bleeding (1)
Barik et al. [29]	2024	Panfacial injury	1	Seldinger's technique with Griggs forceps used, instead of a dilator, to dilate the oro-cutaneous tract.	None
Troise et al. [30]	2024	Complex maxillofacial trauma	21	The pilot balloon is not brought out into the submental area; only the tube is extracted using this technique.	Oral floor infection (1), unaesthetic skin scar (1)
Kiran et al. [31]	2024	Panfacial fractures	1	Preventing pilot balloon blockage by using an intravenous cannula cap or adhesive plaster to cover the deflated pilot balloon tip before exteriorization.	None
Oda et al. [32]	2024	Sturge-Weber syndrome	1	Tip of the tube was wrapped with a sterilized echo probe and secured with a rubber band before passing it through the submental tunnel.	None

The number of patients with reported complications is indicated in parentheses. ETT: endotracheal tube, LMA: laryngeal mask airway, N/A: not applicable, SDCCD: sterile disposable camera cable drape.

tures [6]. The first ETT was used for oral intubation, while a second reinforced tracheal tube was inserted intraorally through a submental incision to replace the initial oral tube.

In 1999, a midline approach behind Wharton's duct was proposed to reduce bleeding and minimize damage to structures in patients with craniomaxillofacial trauma or undergoing orthognathic surgery [8].

In 2000, successful placement of the LMA Flexible™ (Teleflex) through the submental route was reported in patients with maxillary, alveolar, and nasal fractures. This LMA features a reinforced tube, except for the laryngeal sealing area, making it flexible enough for submental insertion [9].

Between 2001 and 2010

In 2002, a modified SSI technique using a laterosubmental (submandibular) incision was reported in cases of panfacial

fractures and orthognathic surgeries [10].

In 2003, successful SI using a Combitube® (Tyco-Healthcare-Kendall-Sheridan) was reported in a patient with severe maxillofacial trauma. This technique was especially useful in cases with significant oral cavity bleeding and unstable cervical fractures [11]. In the same year, a technique was introduced to minimize tube and balloon injuries during SI in patients with multiple facial fractures by inserting the tube into the submental passage while covering the proximal end of the ETT with a blue cap from a 33 Fr thoracic catheter [12].

In 2004, a case was reported where, during the conversion of SI to oral intubation after surgery in a patient with multiple facial fractures, the balloon detached. A 20G needle connector was used to connect a new pilot balloon to the ETT, allowing for continued oral intubation [13].

In 2005, SI was performed without complications using

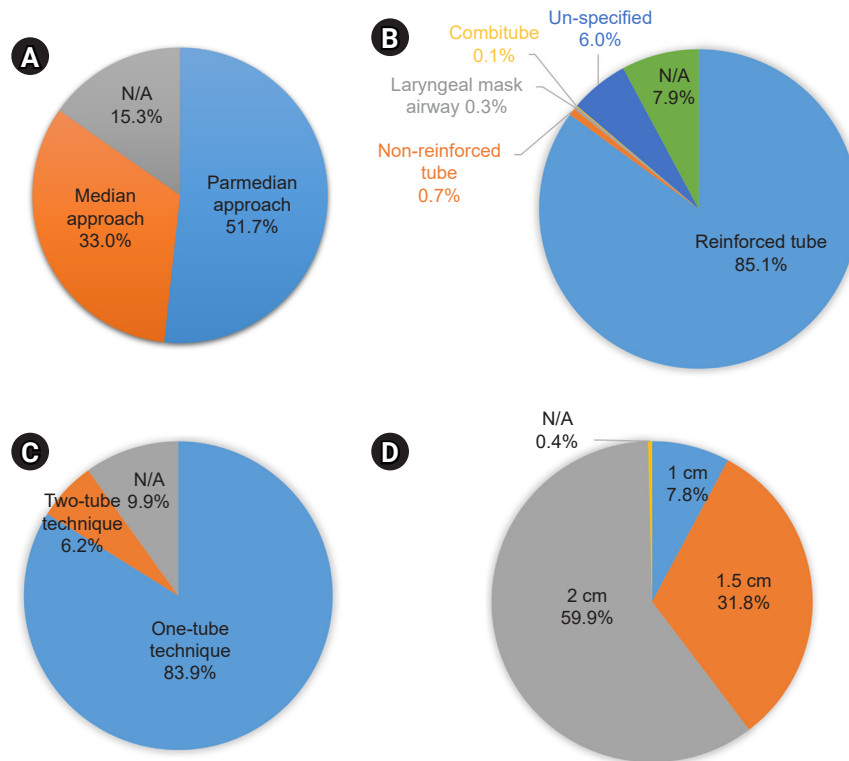


Fig. 2. Analysis of techniques and equipment used in submental/submandibular intubation. (A) Methods of incision approach. (B) Devices used. (C) Number of tubes used. (D) Length of the skin incision. The graph is based on data from articles by Goh et al. [5], and Lim et al. [7]. In submental/submandibular intubation, the paramedian approach was used in 51.7% of cases, with reinforced tubes being the most common (85.1%), and the one-tube technique was favored in 83.9% of cases. Incision lengths varied, with 2 cm being the most used in 59.9% of cases. N/A: not applicable.

the LMA-Fastrach™ (LMA Co.) in patients with panfacial and midfacial fractures to prevent issues such as tube obstruction, accidental extubation, or cuff damage associated with conventional ETTs [14].

In 2006, a slight modification of Altemir's technique, termed "submento-submandibular intubation," was introduced for patients with panfacial injuries. This involved creating passages in the anterior submandibular area for double tracheal intubation, allowing for surgery without major complications [15]. However, minor complications were reported, including suppuration at the scar site in 11 patients (10.3%), salivary fistula in 8 patients (7.5%), and reintubation due to cuff breakage of the second tube in 6 patients (5.6%). These issues were largely attributed to surgical technique errors, suggesting the need for better training and stricter aseptic practices [15]. A study published that same year proposed the '222 rule,' which involved making a 2 cm long incision, 2 cm away from the midline, and 2 cm medial and parallel to the mandibular margin using a sterile nylon guiding tube. This method was reported to have no complica-

tions [16]. In 2006, another technique was introduced to reduce the incision size in the submental area using a dilator from a percutaneous dilational tracheostomy kit (Cook Medical) to widen the passage for tube insertion [17].

Between 2011 and 2020

In 2011, a method was proposed to prevent blood or soft tissue from entering the tube during SI in patients with maxillofacial injuries. This involved covering the proximal end of the tube with a surgical glove finger and passing it through the tunnel [18]. In 2014, a technique using the Seldinger technique, similar to the placement of a central venous line with a needle, guidewire, and dilator, was described [19].

In 2016, a report discussed the insertion of a slightly larger, 12 mm outer diameter silicone tube into the submental tunnel in patients with maxillofacial fractures, through which an ETT could be passed [20]. Most patients showed satisfactory outcomes, with minor complications observed in two cases of skin infection and one case of tube dislodgement

into the right main bronchus. The skin infections could likely be prevented with proper training and stricter attention to aseptic technique. To prevent tube dislodgement into the right main bronchus, it is crucial to perform auscultation to confirm the tube's position after completing the oral-to-submental switch, as the tube tends to migrate during the procedure [20].

In 2017, a technique was introduced for securing the submental passage in patients with midface injuries using the Blue Rhino® (Cook Medical) device from a percutaneous tracheostomy set. This method involved dilating from an extra-oral to intra-oral direction and then reversing the dilator to dilate from intra-oral to extra-oral while passing the disconnected proximal tip of the ETT through the tube connector. The dilator is inserted through the passage along with the tube, reducing trauma to surrounding tissues [21].

New methods have been introduced to prevent the creation of multiple tunnels during submental dissection, where balloons and ETTs may exit through different tunnels. In 2018, a technique was presented for patients with panfacial fractures. Before passing the ETT through the submental tunnel, a 2-0 silk suture was threaded through the tunnel in an extra-oral direction with two forceps placed approximately 10 cm apart. The silk suture was then grasped intra-orally, pulling the proximal end of the forceps through the tunnel into the intra-oral position to secure the balloon passage. The tube was subsequently grasped with the remaining forceps at the distal end, ensuring that the balloon and tube passed through a single tunnel [22]. One case of erroneous passage occurred, which was attributed to a technical error during the initial application of the method [22].

In 2020, a report described using a 12-mm diameter lumen of a laparoscopic trocar for submental tunneling in patients with fractures of the zygomaticomaxillary, zygomatic arch, and right inferior orbital floor. The trocar's lumen was used to pass the ETT from a skin-to-oral direction through the submental tunnel [23]. Also, in the same year, a sterile disposable camera cable drape called Sani-sleeve™ (SDCCD) (Dasol International) was introduced to pass the tube through the tunnel. The use of SDCCD ensures aseptic conditions, prevents infections, and also avoids the aspiration of blood or soft tissue into the ETT. Moreover, using SDCCD allows both the pilot balloon and ETT to pass through a single tunnel, reducing complications associated with conventional methods [24].

Several advancements in SI techniques were reported. In 2020, a method was introduced to handle reinforced ETTs

where the connector cannot be detached, involving excising the connector with a scalpel and replacing it with a smaller connector [4]. In the same year, a technical strategy was implemented using a conical punch device, coupled cylinder pliers, tongue retractor, and drilling guide to reduce difficulties encountered with the conventional Altemir technique when transposing the tube from the oral to submental area [25].

Between 2021 and 2024

In 2022, Jeon et al. [26] proposed five methods. The first involved using a nelaton catheter for submental tunneling in patients with specific facial fractures, but it faced challenges with unintended catheter detachment. The second method involved connecting a suction plastic connector to the tube's proximal end for passage through the tunnel in panfacial fracture patients, but issues arose with plastic connector breakage and tube complications. The third approach confirmed the single-route passage of the pilot balloon and ETT using a black silk and dental needle cap fixation, enhancing stability during SI in facial fracture cases. The fourth method used a nasal speculum to widen the submental tunnel in traumatic subarachnoid hemorrhage patients, while the fifth utilized a laparoscopic trocar for submental tunneling in cases of traumatic subdural hemorrhage [26]. During the application of these methods, one case of nelaton catheter separation, one case of broken suction connector, and one case of dual submental routes with damaged soft tissue were reported. The authors recommended the laparoscopic trocar method as a reliable and straightforward approach for securing a single submental route, despite its higher cost. They also suggested that the nasal speculum could be a cost-effective alternative [26].

The results of a prospective study comparing the complication rate between the method using the conical punch device, coupled cylinder pliers, tongue retractor, and drilling guide by Silveira et al. [25] and the conventional SI technique by Altemir were published in 2022 [25,27]. The study included 42 patients with midfacial or panfacial fractures, and there were no significant differences in complications such as tube dislocation, unesthetic scars, localized hematomas, and skin infections between the techniques ($P = 0.602$) [27].

By 2023, an ultrasound-guided technique had been introduced for panfacial trauma patients, improving tunneling precision and reducing complications associated with blind

techniques [28]. Only one patient experienced minor bleeding, which was controlled with local pressure, with no vascular injury noted [28]. This emphasizes the importance of ongoing practitioner training and assessing bleeding tendency before the procedure to prevent major bleeding.

In 2024, as an alternative to the expensive percutaneous dilatational tracheostomy kit for submental tract dilation during SI in patients with panfacial injury, a method was proposed using Griggs forceps for dilation along the guide-wire, with artery forceps used to guide the tube through the tract to the submental area [29]. In the same year, a technique was proposed for SI in patients with complex maxillofacial trauma to protect the pilot balloon. Instead of bringing the pilot balloon into the submental area, only the tube was extracted, with the pilot balloon thread routed behind the last tooth to prevent interference during maxillary-mandibular fixation [30]. Another study introduced a novel technique for preventing pilot balloon blockage during SI in patients with panfacial fractures. This technique involved using an intravenous cannula cap or adhesive plaster to cover the deflated pilot balloon tip before exteriorization, preventing blood and tissue debris from obstructing the one-way valve and ensuring complication-free intubation [31]. In a patient with Sturge-Weber syndrome, who had angiomas on the upper lip and maxillary gingiva, SI was performed for orthognathic surgery. In this case, the tube tip was wrapped with a sterilized echo probe and secured with a rubber band before passing it through the submental tunnel [32].

A prospective study involving 60 patients with maxillofacial injuries was published, comparing the traditional Altemir method with the Seldinger technique using a percutaneous dilatational tracheostomy kit for submental tunneling. The study found that the Seldinger technique was safer and faster. The mean procedure time was shorter with the Seldinger technique (220 s vs. 170.5 s; $P = 0.040$), and the mean disconnection time was also shorter (12 s vs. 19 s; $P = 0.036$). Additionally, significant bleeding was less frequent in the Seldinger technique group (53.8%) compared to the Altemir technique group (25.9%) [33].

Following the chronological overview, it is essential to compare the different techniques developed within SSI, focusing on specific advancements and their clinical implications. While the fundamental principles of SSI have remained consistent since its inception, several techniques have evolved to address unique clinical challenges.

One-tube vs. two-tube techniques

The one-tube technique, initially described by Altemir [1] in 1986, involves withdrawing the oral intubation tube through a submental incision. This method is often preferred for its simplicity and effectiveness, particularly in maxillofacial trauma cases where time and efficiency are critical. However, in more complex cases, such as those involving extensive facial fractures, the one-tube method can present challenges, particularly the risk of tube dislodgement during the procedure. To address these challenges, the two-tube technique was introduced later by Green and Moor [6]. This method involves first securing the airway with a conventional oral tube, followed by the insertion of a second tube through the submental tunnel. The second tube reduces the risk of dislodgement during the transition and provides additional stability, particularly in cases where the surgical field is compromised or reinforced tubes with non-removable connectors are used. While this technique offers increased safety in complex cases, it requires greater technical expertise and longer procedural time, which may limit its use in some clinical settings.

ETT vs. LMA usage

ETTs remain the primary choice for SSI due to their ability to provide secure and controlled airway management in complex surgeries, particularly in patients with significant facial trauma or during procedures expected to have long durations. ETTs offer a reliable seal within the trachea, which is crucial for maintaining airway patency, especially in cases with a risk of aspiration, hemorrhage, or prolonged mechanical ventilation. This makes them the preferred option in more invasive and high-risk surgeries, such as maxillofacial reconstruction, where airway stability is paramount. However, in certain cases where a less invasive approach is appropriate, LMAs have been successfully utilized [9,14]. LMAs provide a simpler and less traumatic method of airway management, particularly in procedures where avoiding the more invasive nature of ETTs is beneficial. For instance, LMAs like the LMA Flexible™ are designed to be more flexible, allowing for easier insertion with reduced trauma to the patient's airway structures. While LMAs do not offer the same level of protection against aspiration as ETTs, they can provide sufficient ventilation support during less critical procedures, and their ease of use and reduced insertion trauma make them an attractive option in these specific cases.

Evolution of tools used in SSI

Over the years, the tools used in SSI have undergone significant advancements. The single tunneling approach in SSI has seen improvements aimed at enhancing precision, safety, and reducing complications such as tube kinking and infection. Early procedures used basic instruments like curved hemostats and nasal speculums [1,2,26]. However, with the advent of new technologies, more sophisticated tools such as percutaneous dilatational tracheostomy kits, laparoscopic trocars, nelaton catheters, and Sani-sleeve™ sterile disposable camera cable drapes have been introduced [17,19,21,23,24,26,29]. Additionally, the integration of ultrasound guidance has revolutionized SSI by enabling real-time visualization of anatomical structures, minimizing risks during complex intubations [28]. One of the most notable recent advancements in SSI is the integration of ultrasound guidance, particularly for tunneling during complex maxillofacial surgeries. Ultrasound guidance allows for real-time visualization of anatomical structures, significantly reducing the risk of complications such as vascular injury or improper tube placement. This method has shown promising results in improving the safety and accuracy of SSI intubation.

INDICATIONS AND CONTRAINDICATIONS of SSI

In most surgeries, orotracheal intubation is performed, but it has its own contraindications, including upper airway obstruction, restricted mouth opening, surgeries requiring occlusal alignment (such as jaw surgeries), and situations where the orotracheal tube interferes with the surgical procedure [5,7,34-40]. Most dental surgeries are conducted within the oral cavity, making nasotracheal intubation the usual approach. However, contraindications for nasotracheal intubation include nasal abnormalities such as nasal bone fractures, skull base fractures, nasal masses, bleeding, and Le Fort II or III fractures [5,7,34-43]. The primary reason for performing SSI is when both orotracheal and nasotracheal intubations are impossible, and tracheostomy is not indicated. Contraindications for tracheostomy include bleeding diathesis, local infection, anatomical abnormalities, and difficult landmarks [34]. In craniofacial surgeries requiring prolonged mechanical ventilation for more than seven days, or in cases of severe polytrauma or neurological injury, tracheostomy is typically performed. For shorter durations of me-

chanical ventilation, either oral or nasal intubation is preferred. When both orotracheal and nasotracheal intubations are contraindicated, SSI is considered an alternative [5,35-39,41-43]. SSI is generally indicated for elective craniofacial, maxillary, nasal, orthognathic, and aesthetic face surgery, as well as situations where dental occlusion is needed, mouth opening is adequate, nasal intubation has failed, or there is a large pharyngeal flap. Contraindications for SSI include infection or injury in the submental area, bleeding diathesis, laryngotracheal disruption, severe neurodeficit, prolonged need for airway maintenance and/or ventilation (> 7 days), gunshot injuries, inadequate mouth opening, keloid-prone skin, and laryngotracheal disruption [7,34,40].

A previously mentioned review paper published in 2018 examined nearly all the literature on SI published from 1986 to 2016 [7]. The review identified 70 articles and included a total of 1,021 patients. The included literature consisted of 21 case reports, 16 case-series, 11 prospective studies, 21 retrospective studies, and one technical note. The indications for SSI among these 1,021 patients are illustrated in Fig. 3, which has been visually restructured for clearer presentation. Maxillofacial fractures accounted for the majority at 86.9%, followed by orthognathic surgery at 5.8%, skull base surgery at 2.8%, and nasal surgery at 1.5% [7]. Another review paper published in 2020 included a total of 116 studies and 2,229 patients who underwent SSI. According to the results, which mirrored earlier research, the most common reason for performing SSI was trauma (81%), particularly multiple or complex facial fractures. Orthognathic surgery was the second most common reason (15%). Other indications included diseases such as tumors, fibromyoxoma, and fistulas, as well as cosmetic surgery [5]. Among the most

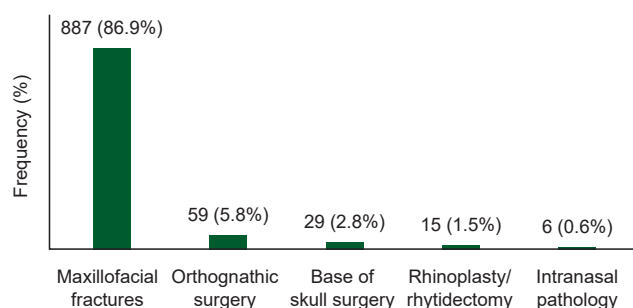


Fig. 3. Frequency analysis of submental/submandibular intubation procedures. The graph is based on data mentioned in the article by Lim et al. [7]. For the indications for submental/submandibular intubation, maxillofacial fractures accounted for the majority, followed by orthognathic, skull base, and nasal surgery.

common maxillofacial fractures, cases involving Le Fort fractures or skull base procedures often necessitate SSI. This is because nasotracheal intubation is not feasible due to the fracture, and orotracheal intubation is not possible as maxilomandibular fixation is required during the surgery.

Therefore, the practical applications of SSI are primarily in cases where conventional intubation methods, such as orotracheal or nasotracheal intubation, are contraindicated or pose significant challenges. SSI is particularly advantageous in managing difficult airways during maxillofacial trauma surgeries, orthognathic surgeries, and other facial reconstruction procedures. For instance, when there is a need to maintain occlusal alignment during surgery or when access to the oral or nasal cavity is restricted due to fractures, SSI offers a viable alternative. Additionally, these methods may be preferred over tracheostomy in cases where minimizing visible scarring and reducing recovery time are priorities. The choice of SSI can be influenced by specific anatomical considerations, with the submandibular approach often being utilized when a paramedian route provides safer access. By delineating these clinical scenarios, the use of SSI can be more effectively integrated into practice, ensuring its application is optimized based on patient-specific factors and surgical requirements.

TRACHEOSTOMY vs. SSI

In maxillofacial surgery, a comparison between tracheostomy and SSI highlights the necessity and advantages of SSI, as shown in [Table 2](#).

Tracheostomy offers the advantage of prolonged airway maintenance, making it suitable for cases requiring long-term airway management, particularly when mechanical ventilation is needed for more than seven days due to severe polytrauma or neurological injury. However, tracheostomy is associated with significant complications, including bleeding, infection, unaesthetic scars, surgical emphysema, pneumothorax, pneumonia, tracheal stenosis, and tracheomalacia. The incidence of early complications is 6–8%, while long-term complications occur in up to 60% of cases, often with severe outcomes [7,44]. On the other hand, SSI is advantageous due to its simplicity and speed. The procedure is relatively straightforward, time-efficient, and avoids the need for tracheostomy, thereby preventing associated complications. Postoperative benefits of SSI include not requiring extensive airway care, resulting in a shorter hospital stay and making it more cost-effective. Aesthetically, SSI leaves a

less noticeable scar compared to tracheostomy. Functionally, it aids in assessing occlusion during surgery with minimal soft tissue distortion [5,7,34,40,44–46].

Despite these benefits, SSI also has potential complications, though they are generally mild and short-term compared to those of tracheostomy. These complications include infection, scarring, fibrosis, salivary fistula, sialoceles, mucocoele, tube displacement or kinking, desaturation, bleeding, and accidental extubation [5,7,25,40,47–49]. In one study, 91% of patients experienced no complications, with infection being the most common at 3.5%, followed by scar-related issues at 1.2%, and salivary fistula at 1.1% [7]. Another review of 2,229 patients showed an overall complication rate of 6.8%, with infection being the most frequent at 2.4% [5]. A retrospective study indicated that complications associated with SI are exacerbated by factors such as smoking (odds ratio [OR] = 691.8) and moderate to high gingivitis (OR = 786.7), and reduced by the use of chlorhexidine mouthwash postoperatively (OR = 0.03) [50].

A prospective study comparing SI and tracheostomy in maxillofacial fracture patients who could not undergo nasotracheal intubation found significant differences [45]. Among 32 patients, those in the SI group had an average procedure time of 8.35 min compared to 30.75 min in the tracheostomy group, highlighting the time efficiency of SI ($P < 0.001$). Despite using standard ETTs, complications such as tube kinking occurred in 10% of SI cases, while 15% of tracheostomy patients experienced surgical emphysema. Scar revision was required in 20% of tracheostomy cases but not in SI cases ($P = 0.033$) [45]. Clinically, using flexometallic tubes for SI can prevent tube kinking, further reducing complication rates.

FUTURE OF SSI

The concept of SI, first introduced in 1986 by Altemir [1], marks a significant milestone in anesthetic technology. Since its introduction, SSI has advanced in several areas, including refinement of the technique and improvements in equipment. The precision of incision location, size, and the intubation pathway has increased, with more sophisticated tools making the procedure safer and more efficient.

Following its initial success, SSI began to be used in various clinical situations. It became particularly useful for patients with severe facial trauma or those for whom traditional oral or nasal intubation was challenging. Research on the efficacy of SSI was conducted within the anesthetic field, as

Table 2. Advantages, Disadvantages, and Complications of Tracheostomy and Submental/Submandibular Intubation [5,7,25,34,40,44,45,47-49]

Advantage	Disadvantage/Complications
Tracheostomy	
Long-term airway maintenance (more than 7 days)	Bleeding Infection Unaesthetic scar Surgical emphysema Pneumothorax Pneumonia Tracheal stenosis Tracheomalacia Expensive Challenging to perform in adults with goiter or pediatrics Requires special postoperative management Time-consuming
Submental/submandibular intubation	
Simple surgical technique and short procedure duration	Infection
No need for airway care after surgery	Scarring
Relatively short hospital stays, making it cost-effective	Salivary fistula
Aesthetic scar	Mucocele
Assists in assessing occlusion during surgery	Sialocele
Relatively minimal distortion of soft tissue	Fibrosis
Relatively few motor/sensory deficits	Dislodged tube Tube pushed into bronchus Tube kinking Desaturation Bleeding Accidental extubation Pain Pilot tube damage Sublingual hematoma Submental swelling Increased airway pressure during surgery Not suitable for multiple-time surgery (inappropriate for reoperation, reexploration)

discussed in the papers covered in this review article. These studies provided a clearer understanding of the safety, effectiveness, and potential complications of SSI. Today, SSI techniques have evolved by integrating modern medical technologies such as ultrasound.

In contemporary anesthetic practice, SSI remains a vital airway management method in specific situations. It plays a crucial role in facial reconstruction surgeries, oral cancer surgeries, and the treatment of severe facial trauma. However, there are several specific areas where further research could significantly advance SSI. For example, exploring the integration of imaging technologies, such as 3D navigation

systems and augmented reality, could offer more precise and safer procedural guidance, helping to prevent complications like tube kinking or misplacement. Additionally, developing novel intubation devices made of more flexible and durable materials could improve patient outcomes while minimizing equipment-related issues.

Clinical trials comparing SSI with other airway management techniques, such as standard endotracheal or fiberoptic intubation, in specific surgical settings could help establish clearer guidelines for their use. Investigating cost-effective yet reliable alternatives for equipment and determining their practicality in different healthcare settings, especially

in low-resource environments, could also provide important insights.

Moreover, studying patient-specific factors that may influence the success or complication rates of SSI, such as anatomical variations or the impact of pre-existing conditions like obesity or head and neck cancers, could be valuable. As medical technology continues to evolve, exploring ways to better integrate SSI with new innovations will help optimize patient safety and outcomes. Future research should also aim at refining protocols and standardizing training to ensure that evolving techniques are consistently applied across different clinical settings.

With ongoing innovation and clinical experience, SI will likely continue to evolve as a key method in airway management.

CRITICAL ANALYSIS

While numerous studies have contributed to the understanding of SSI, the quality of evidence varies. Many of the studies are case reports or series, largely due to the nature of the clinical situations where SSI is required. Conducting comparative studies between SSI and other intubation techniques is often challenging, as patient safety may be at risk during such comparisons. As a result, few studies have directly compared SSI with other airway management methods or different techniques used within SSI, and much of the existing evidence lacks the rigor of randomized controlled trials [20,27,33,45,46]. Moreover, the studies reviewed often present limitations due to their non-randomized designs and small sample sizes, which may introduce bias. Additionally, many of these studies were conducted in specific institutions or regions, affecting the generalizability of the results. For instance, several studies focused on unique patient populations or specific surgical settings, limiting their applicability to broader clinical practice. Furthermore, even when the same SSI is performed, variations in technique can lead to differing outcomes, further complicating the interpretation and comparison of results.

Comparing the outcomes of SSI with other techniques reveals varying levels of effectiveness and complication rates. While some studies suggest that SSI offers a lower risk of long-term complications compared to tracheostomy, others indicate that challenges such as tube displacement or infection are still prevalent.

Future research should aim to conduct larger, well-designed studies to provide more robust evidence on the effi-

cacy and safety of SSI, though ethical considerations will remain a key challenge in designing such research.

CONCLUSION

Various techniques of SSI from past to present have been explored, and it is evident that each method has its advantages and disadvantages. Therefore, it is crucial for surgeons and anesthesiologists to communicate closely and choose the most appropriate method for each situation. Despite the advancements, the need for further research is evident, given the relatively low number of studies compared to other intubation methods. As SSI continues to evolve, incorporating new technologies and techniques, it holds promise for becoming a more widely adopted practice in appropriate surgical contexts, balancing safety, efficiency, and patient outcomes effectively. SSI is no longer an unfamiliar and fearful procedure for anesthesiologists but rather a necessary and familiar method of airway management for certain patients.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

Writing - original draft: Kyung Nam Park. Writing - review & editing: Myong-Hwan Karm. Conceptualization: Kyung Nam Park, Myong-Hwan Karm. Data curation: Kyung Nam Park, Myong-Hwan Karm. Formal analysis: Kyung Nam Park, Myong-Hwan Karm. Methodology: Kyung Nam Park, Myong-Hwan Karm. Project administration: Myong-Hwan Karm. Visualization: KN Park, Myong-Hwan Karm. Investigation: Myong-Hwan Karm. Resources: Myong-Hwan Karm. Software: Kyung Nam Park, Myong-Hwan Karm. Supervi-

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